System Design for a Mission Analysis System

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This paper is a synopsis of an on-going GSFC contract to design a mission analysis system. The design is specifically for an IBM 360, however, the concepts herein may be employed on any large machine. The system is to include:

- o Mission Profile Generation,
- o Parametric Scans,
- o Maneuver Analysis,
- o Targeting and Optimization,
- o Monte Carlo.

In addition, these functions are to be performed in both the batch and interactive modes. Additional design considerations are that the system is to be:

1. User oriented;
2. Easily extendable;
3. Use common elements to minimize software maintenance;
4. Available for pre-mission design and operation;
5. Use existing software wherever possible;
6. Use existing data base;
7. Restricted to 200-300K bytes.

Also, the system is to offer a large number of trajectory propagators, maneuver routines, etc., and ultimately be able to support various types of missions. As shown in Figure 1, mission profile functions can be divided into trajectory propagators, stopping conditions, parameters, maneuver implementation and maneuver computations. Therefore, any profile can be computed at the desired accuracy by proper selection of the available options. In order to take advantage of this fact and also to satisfy most of the design consideration, a table-driver-interactive-graphic executive is proposed.

SYSTEM EXECUTIVE

Thus the executive processes an input table of names and executes the corresponding independent modules or programs. The communications between modules is through either files or dynamically allocated arrays. These arrays essentially form an addressable common data base which can be processed by input. This allows the executive to perform logical IF test on these variables and branch to a defined statement in the input stream. It also gives the user the ability to set dynamic data base variables and to copy one variable into another. Also, the executive processes DO LOOP instructions to facilitate parametric scan operations.

The executive stores and retrieves from disk both default data for each module which requires input and named tables of input module names called automatic sequences. After each module name, which may be up to 16 characters, updates to the default data may be inserted. This allows the user to tailor the input to a specific problem. In addition, he has the option to update the input data at execution time (case dependent input) either through cards in the batch mode or through the CRT at execution time. Each automatic sequence may be thought of as an applications program, however, all programs (sequences) in the system use the same identical modules when referencing a module name.

Interactive graphics are supplied through the GESS executive, a Graphics Executive Sub-System existent at GSFC. The system supports graphics displays which may be defined for each module, but most importantly, allows the user to communicate and re-direct the program on a near real time basis.

The entire system is data base driven. All constants, including π, astronomical constants, ephemeris data are retrieved from a single source. Each module must read this file to load all constants.

In order to perform the targeting and optimization function, the executive will process all modules which follow after reference to

the targeting and optimization function until either an end of data or reference to the profile function or Monte Carlo is made. The control parameters and the dependent variables (function to be minimized or optimized) are stored in a specified dynamic data base variable. This may be done directly in the first guess module and error function module or may be done by an executive utility which allows any array to be copied into a specified array. Consequently, the trajectory problem defined by the module names simply becomes a function of n independent and m dependent variables. Hence, targeting and optimization is not locked into any one problem, but may be applied to any problem. The targeting and optimization routines themselves utilize frequent use of dynamic data base variables in order to conserve core. Use of dynamic variables throughout the system wherever possible will hopefully minimize core requirements and prevent routines from having to be recomplied simply to increase the dimension of a variable. In this system, any profile or trajectory may be Monte Carloed by including three routines: a covariance sampling routine, a random sample generator to perturb either the maneuver controls or trajectory state, and a routine to compute statistical summary information. If desired, a covariance reconstruction routine may be included to ensure that the distribution fo samples compares with the original covariance. Statistical summary information may be computed for any variable stored in a data base variable.

- MISSION PROFILE GENERATION
- PARAMETRIC SCANS
- MANEUVER ANALYSIS
- TARGETING AND OPTIMIZATION
- MONTE CARLO

Figure 1. Mission Analysis Functions.

1. USER ORIENTED
2. INTERACTIVE - GRAPHICS (BATCH)
3. EXTENDABLE TO NEW MISSION
4. USER COMMON ELEMENTS
5. AVAILABLE FOR BOTH PRE-MISSION DESIGN & OPERATIONS
6. MAKE USE OF EXISTING SOFTWARE WHEN POSSIBLE
7. INTERFACE WITH EXISTING DATA BASE
8. 200 - 300K BYTES

Figure 2. System Features.

MISSION PROFILE & PARAMETRIC SCAN FUNCTION

TRAJECTORY PROPAGATORS	STOPPING CONDITIONS TRAP & FIRST GUESS	PARAMETERS	MANEUVER MANEUVER IMPLEMENTATION	MANEUVER MANEUVER COMPUTATIONS
TWO BODY	TIME	STATION COVERAGE	IMPULSIVE	MISSION INDEPENDENT
⋮	ALTITUDE	GROUND TRACK	ANALYTIC FINITE BURN	IMPULSIVE
⋮	LONGITUDE	BETA ANGLE	FINITE BURN	ANALYTIC FINITE BURN
BROWER	APOGEE	ASPECT ANGLE		THRUST POLY.
⋮	PERIGEE	⋮		
⋮	⋮	⋮		MISSION DEPENDENT
⋮	⋮	⋮		TANK SELECTION
COWELL	⋮	SHADOW		JET SELECTION
	LATITUDE			FLOWRATE
	MAX DECLINATION			ROTATING S/C MODEL

DATA BASE

CONSTANTS - TT, N, J_{22}, C_{mm}, S_{nn}

EPHEMERIS - CELESTIAL BODIES, SPACECRAFT

SPACECRAFT DATA - WEIGHT, CONSUMABLES

TARGETING & OPTIMIZATION

FIRST GUESS MANEUVER ROUTINE

TARGET & FUNCTION DEFINITION ROUTINE

MONTE CARLO

COVARIANCE SAMPLING
- CORRELATED
- UNCORRELATED

RANDOM SAMPLE GENERATION

STATISTICAL SUMMARY ROUTINE

COVARIANCE RE-CONSTRUCTION

Figure 3. System Functional Analysis.

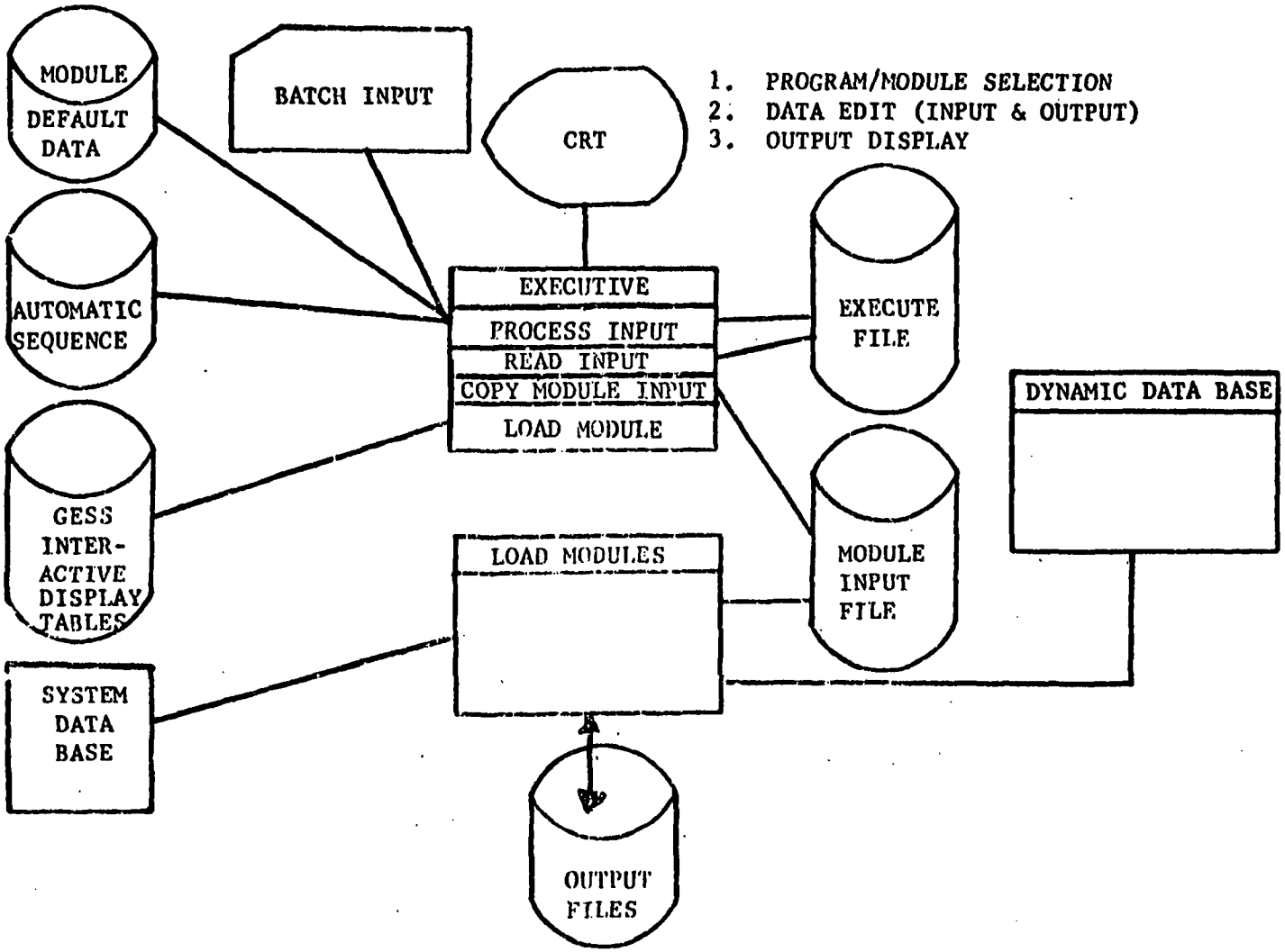

Figure 4. Mission Analysis System Flow Diagram.

DEFAULT INPUT

GMAS INPUT
1. ARRAY ALLOCATION/DEALLOCATION
2. DISPLAY SPECIFICATIONS
MODULE 1 DEFAULT INPUT
:
GMAS INPUT
MODULE 2 INPUT
:
MODULE (N) DEFAULT

AUTOMATIC SEQUENCE

MODULE 1
CHANGES TO DEFAULT FOR MODULE 1
MODULE 2
IF (ENERGY LT. CIRCULAR) GOTOA
MODULE 3
CHANGES TO DEFAULT FOR MODULE 3
MODULE 4

GMAS UPDATE
MODULE 4

LABEL A
MODULE 5

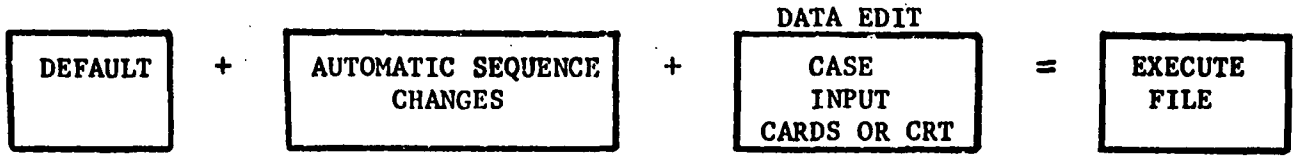

Figure 5. Execute File.

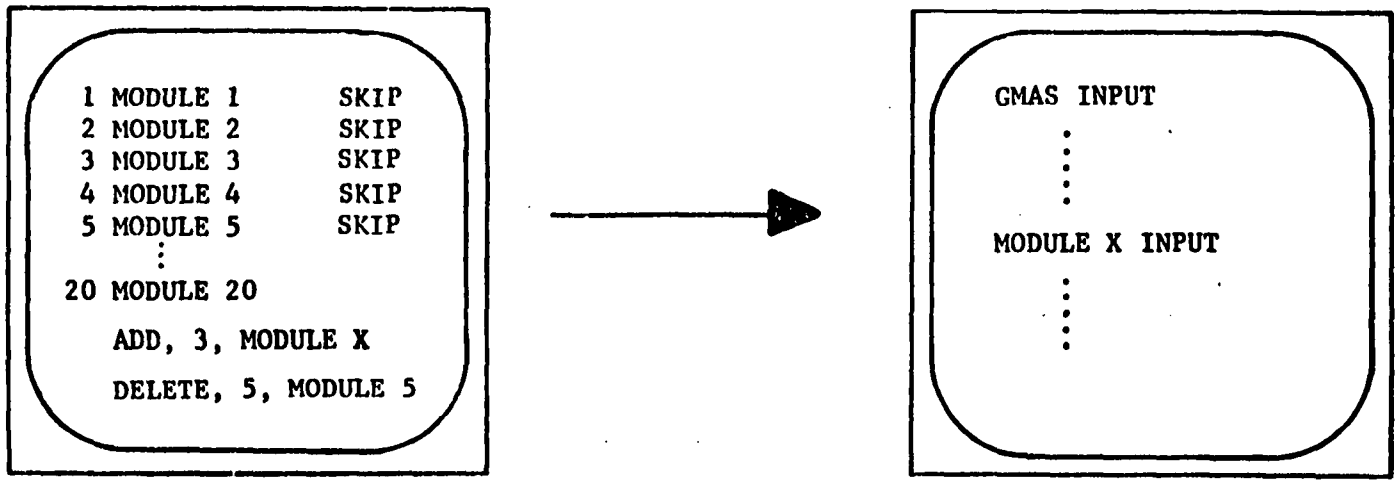

Figure 6. Data Edit.

GMAS SAMPLE INPUT

```
COLUMN NUMBER
          1         2         3         4         5         6
1234567890123456789012345678901234567890123456789012345678901234567890

 $EXEC BATCH=1,,
 UTIL(13)=8HSETDBV  ,8HAFBM    ,8HCONIC   ,8HTARMAP  ,
 NUT=17, $END
SEQUENCE
PROFDR
PROFCON
SETDBV
 $GMAS
 NAMEA = 'IFLAG','TARGETS','CONSTS',
 IDIMA =  1,1,1,4,1,1,5,1,1,
 ITYPA =  1,1,1, $END
 $SETDB
 DBVNAM =6HCONSTS, LENGTH = 4, RB= 398600.7318, 6378.16,
 6378.16, 57.2957795130,
 DBVNAM(2)=5HIFLAG,LENGTH(2)=1,RB(1,2)=0.0,
 NDBV = 2,
 $END
PRINTV
 $PRINT
 NAMEPV=8HCONSTS  ,8HSTATE    ,8HIFLAG     ,FORMT=8HD15.8  ,
 $END
TARGCON
 $TARGC
 SRCHM=4,NINDV=3,NDEPV=4,
 DEPTL=200.,.001,.1,.0,,
 $END
```

Figure 7. GMAS Sample Input.

```
IF ( IFLAG .GT. 0. ) GO TO LAB1
APOMFG
 $GMAS
 ITYPA =1,1,1,
 IDIMA =      7,2,1,9,1,1,6,1,1,
 NAMEA =      'STATE','PHIT','ORBELMS', $END
 $APOMF
 XIT       =  .32775343E4,  .56859240E4, -.21607384E1,
 VXIT      = -.79407125E1,  .45837270E1, -.46073696E1,
 GMU       = 398600.731B,
 DESINC    = .9,
 DESLAN    = 270.,
 DESSMA    = 41704.,
 DESECC    = .02394,
 DVMAG     = 1.746,
 $END
LABEL LAB1
SETDBV
 $SETDB
 NDBV=1,
 DBVNAM=5HIFLAG,LENGTH =1,RA=1.,$END
ORBIT
 $ORBIT
 $END
PRINTV
 $PRINT
 NAMEPV=8HCONSTS  ,8HSTATE    ,8HIFLAG     ,FORMT=8HD15.8   ,
 $END
AFRM
 $AFRM
 MASS=2000., MDOT=25., TBURN =20., THRUST =.0873 , $END
CONIC
TAPMAP
/*
```

Figure 7. GMAS Sample Input (continued).